
PART I - ADMINISTRATIVE

Section 1. General administrative information

Title of project

Strategies For Riparian Recovery: Plant Succession & Salmon

BPA project number: 20057

Contract renewal date (mm/yyyy):

☐ Multiple actions?

Business name of agency, institution or organization requesting funding

Oregon State University

Business acronym (if appropriate) _____

Proposal contact person or principal investigator:

| | |
|-----------------|--|
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NPPC Program Measure Number(s) which this project addresses

sections 2.1, 2.2, 4.1, 7.6, 7.7, and 10.2

FWS/NMFS Biological Opinion Number(s) which this project addresses

Other planning document references

Return to the River (Independent Scientific Group 1996) calls for better efforts to examine influences of riparian vegetation on salmonids and stream food webs.

We are presently working with the Umatilla National Forest in funded projects related to mining restoration, flood effects, stream temperature patterns, and fish distribution.

OSU Extension program is incorporated into this study through the participation of Dr. Reed. Through his office we are cooperating with the Umatilla Basin Watershed Council, Hermiston Irrigation District and private landowners.

Short description

Determines the role of riparian plant diversity, structure and density on fish diet and habitat. Examines temporal and spatial dynamics of riparian inputs and their use by aquatic invertebrates and salmonids.

Target species

inland rainbow trout, sculpin, spring chinook salmon, bull trout, native cyprinids, catostomids, cottids and all other aquatic species in the study reaches

Section 2. Sorting and evaluation

Evaluation Process Sort

| CBFWA caucus | Special evaluation process | ISRP project type |
|---|--|--|
| Mark one or more caucus | If your project fits either of these processes, mark one or both | Mark one or more categories |
| <input checked="" type="checkbox"/> Anadromous fish <input checked="" type="checkbox"/> Resident fish <input type="checkbox"/> Wildlife | <input checked="" type="checkbox"/> Multi-year (milestone-based evaluation) <input type="checkbox"/> Watershed project evaluation | <input type="checkbox"/> Watershed councils/model watersheds <input type="checkbox"/> Information dissemination <input type="checkbox"/> Operation & maintenance <input type="checkbox"/> New construction <input checked="" type="checkbox"/> Research & monitoring <input type="checkbox"/> Implementation & management <input type="checkbox"/> Wildlife habitat acquisitions |

Section 3. Relationships to other Bonneville projects

Umbrella / sub-proposal relationships. List umbrella project first.

| Project # | Project title/description |
|-----------|---------------------------|
| | |
| | |
| | |
| | |

Other dependent or critically-related projects

| Project # | Project title/description | Nature of relationship |
|-----------|--|----------------------------|
| 9405400 | Bull trout genetics, habitat needs, etc. | collaborators in NE Oregon |
| | | |
| | | |

Section 4. Objectives, tasks and schedules

Past accomplishments

| Year | Accomplishment | Met biological objectives? |
|------|----------------|----------------------------|
| | | |
| | | |
| | | |
| | | |

Objectives and tasks

| Obj 1,2,3 | Objective | Task a,b,c | Task |
|-----------|--|------------|---|
| 1 | Analyze historic patterns of vegetation changes in riparian zones of study streams | a | Obtain and analyze present and historical aerial photographs of the study stream basins |
| | | b | Reconstruct changes in structure, density |

| | | | |
|---|--|---|---|
| | | | and extent of riparian zone through time |
| 2 | Examine riparian and stream habitat features associated with riparian stands of different diversity/seral stage | a | Quantify the species and structural diversity of riparian zones along longitudinal gradients |
| | | b | Ground truth aerial photographs |
| | | c | Collect FLIR imagery |
| 3 | Compare terrestrial inputs (litter and invertebrate) from riparian stands differing in plant diversity | a | Quantify timing and biomass of litter infall to streams |
| | | b | Examine nutrient quality of litter inputs |
| | | c | Identify & quantify terrestrial insect assemblages from different plant assemblages (litter fall and drift) |
| 4 | Analyze aquatic invertebrate response to riparian diversity | a | Quantify aquatic invertebrate abundance and diversity through the seasons in drift and benthos at sites of differing seral stage and riparian diversity |
| 5 | Examine differences in native fish densities, diet, and growth rate associated with riparian stands differing in plant diversity | a | Census fish communities at reaches flowing through riparian communities of differing structure, density and extent |
| | | b | Examine pumped fish stomach samples of drift-feeding yoy salmonids |
| | | c | Determine growth rates of yoy salmonids through photogrammetric methods |

Objective schedules and costs

| Obj # | Start date mm/yyyy | End date mm/yyyy | Measureable biological objective(s) | Milestone | FY2000 Cost % |
|-------|-----------------------|---------------------|---|----------------------|------------------|
| 1 | 10/1999 | 9/2000 | historic riparian vegetation | Gis layers | 15.00% |
| 2 | 10/1999 | 9/2000 | present riparian diversity | riparian composition | 25.00% |
| 3 | 10/1999 | 9/2000 | terrestrial inputs; quantity, quality | | 20.00% |
| 4 | 10/1999 | 9/2000 | invertebrate diversity and composition | | 20.00% |
| 5 | 10/1999 | 9/2000 | fish abundances, gut contents | | 20.00% |
| | | | | Total | 100.00% |

Schedule constraints

streamflow conditions for field sampling

Completion date

2003

Section 5. Budget

FY99 project budget (BPA obligated):

FY2000 budget by line item

| Item | Note | % of total | FY2000 |
|---|--------------------------|-------------------|------------------|
| Personnel | | %37 | 157,090 |
| Fringe benefits | | %10 | 44,825 |
| Supplies, materials, non-expendable property | | %14 | 58,500 |
| Operations & maintenance | | %0 | |
| Capital acquisitions or improvements (e.g. land, buildings, major equip.) | | %0 | |
| NEPA costs | | %0 | |
| Construction-related support | | %0 | |
| PIT tags | # of tags: | %0 | |
| Travel | | %6 | 25,000 |
| Indirect costs | | %22 | 96,128 |
| Subcontractor | | %6 | 25,000 |
| Other | graduate student tuition | %5 | 22,920 |
| TOTAL BPA FY2000 BUDGET REQUEST | | | \$429,463 |

Cost sharing

| Organization | Item or service provided | % total project cost (incl. BPA) | Amount (\$) |
|---|---------------------------------|---|--------------------|
| USDI/USGS | .25 FTE for Hiram Li | %4 | 16,450 |
| | | %0 | |
| | | %0 | |
| | | %0 | |
| Total project cost (including BPA portion) | | | \$445,913 |

Outyear costs

| | FY2001 | FY02 | FY03 | FY04 |
|---------------------|---------------|-------------|-------------|-------------|
| Total budget | \$420,000 | \$430,000 | \$400,000 | |

Section 6. References

| Watershed? | Reference |
|-------------------------------------|---|
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|-------------------------------------|---|
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| <input type="checkbox"/> | Hynes H.B.N. 1970. The ecology of running waters. University of Toronto Press, Toronto. |
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| <input type="checkbox"/> | Johnson, J.H. and N.H. Ringler. 1980. Diets of juvenile coho salmon (<i>Oncorhynchus kisutch</i>) and steelhead trout (<i>Salmo gairdneri</i>) relative to prey availability. Can. J. Zool. 58:553-558. |
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| <input type="checkbox"/> | Li, J.L. 1990. Foraging behavior of the limnephilid caddisfly, <i>Dicosmoecus gilvipes</i> , and co-occurring herbivores in streams of the Pacific Northwest. Ph.D. Dissertation, Oregon State University, Corvallis, OR. 174p. |
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| <input type="checkbox"/> | |
| <input type="checkbox"/> | |

PART II - NARRATIVE

Section 7. Abstract

The precarious standing of many salmonid stocks in the Pacific Northwest demands extraordinary measures to improve the odds for their survival. An important component for habitat restoration is undoubtedly riparian vegetation because it generates plant litter, insect litter and woody structure, as well as providing bank structure and shade. Recent initiatives propose to restore riparian corridors through extensive planting; but we know little of riparian vegetation succession, of the dynamics controlling the seasonal availability of riparian inputs to streams, or how these inputs are connected to the distribution and life cycles of fishes in Oregon watersheds. The proposed study will determine how salmonid fishes respond to riparian diversity, how riparian diversity changes over time and will build a framework for designing riparian restoration programs in northeast Oregon. We will reconstruct riparian community succession by analyzing time series of aerial photographs of riparian zones in different areas, and also use these images to establish study sites of varying composition and age. Differences in seasonal timing and nutritional quality of riparian input will be compared among stands. We will survey both in-stream and riparian zone characteristics of each site, where riparian litter, terrestrial insects, aquatic insects, and fish will be quantified. To study the potential of riparian inputs to fish diet, drift samples and fish stomach contents will be separated into components derived from terrestrial and aquatic sources. Fish growth will be compared between sites to estimate the relative value of these sources.

Section 8. Project description

a. Technical and/or scientific background

Introduction:

Despite an investment of \$3 billion in previous restoration efforts, salmon continue declining to levels of endangerment. The precarious status of 76 stocks of native salmonid fishes was recognized almost a decade ago (Nehlsen et al. 1991), and little has changed. All Columbia River steelhead stocks currently are under review, and bull trout are proposed for threatened status. It is important to recognize an ecological framework from which to base restoration and management decisions (Independent Science Group 1996). Sustainability of salmonid stocks and restoration of stream ecosystems will depend in part on our understanding of important riparian processes and stream food webs interactions (Stanford et al. 1996). Our goal is to increase our understanding of these normative riparian processes and see that they become incorporated into an ecologically based management framework.

One strategy for multiple state and federal programs is to enhance stream restoration efforts through planting riparian vegetation. The most recent program, Conservation Reserve Enhancement Program (CREP), targets significant environmental effects in streams through agricultural areas. Among

the proposals are extensive tree plantings including plantations of rapid growing cottonwood-poplar hybrids which can bring farmers income as a cash crop. Before extensive plans for hybrid poplar plantations and other restoration programs are enacted, it is critical that we understand how riparian inputs are connected to the distribution and life cycles of the aquatic biota.

Riparian zones are a result of spatial and temporal dynamics. Current conditions are set by historical land use as well as natural disturbances, geology, and topography. Riparian zones are integrated into a spatial network. Physical and biological processes in these zones are influenced by forces occurring at watershed and regional scales. Landscape-level restoration efforts, like those proposed for riparian plantings, must include a consideration of these multiple scales. The spatial context may be set by dynamic changes in riparian vegetation, that result from climatic, upstream and/or upslope events. Physical changes induce biological colonization and reorganization at multiple levels. To address these various scales, our study will examine current and historical patterns of riparian succession, interactions between terrestrial and aquatic zones, and upstream/downstream connectivity of diverse areas within watersheds.

Stream Ecology and Riparian Interactions:

Riparian vegetation is an important component of a stream ecosystem and influences multiple aspects of aquatic food webs through inputs of leaves, wood and insect litter (Figure 1). In the Pacific Northwest declining salmonid populations likely depend on both the structural and biological diversity provided by riparian inputs. The importance of riparian vegetation to the function of streams has been recognized for many years (Hynes 1970), particularly as it contributes large woody debris and provides the major energy resource for macroinvertebrates and fishes (Cummins 1974, Gregory et al. 1991, Independent Science Group 1996). Riparian zones are important ecotones between terrestrial and aquatic systems. Allochthonous materials and terrestrial insects transfer energy between these two systems. Riparian zones also serve to filter nutrients, stabilize banks and provide shade for streams (Gregory et al. 1991, Li et al. 1994, Beschta 1997). Surprisingly, specific processes linking the distribution of aquatic organisms with riparian vegetation inputs and cascading effects for the aquatic food web have not been studied on a landscape scale (Behmer and Hawkins 1986, Sweeney 1993, Johnson and Covich 1997).

Resident and anadromous rainbow trout, bull trout and spring chinook reside or migrate through eastside streams despite human alterations of stream habitats. Although salmonids are considered generalist predators, salmonid young of year are primarily insect feeders. The diet of immature chinook salmon has been shown to be 95% insects and immature coho salmon consume about 99% insects (Johnson and Ringler, 1980). Steelhead diets are largely insect as well (Johnson and Ringler, 1980). Young of the year diet is well known to be a combination of terrestrial and aquatic invertebrates; but we know little of the factors contributing to the relative importance of these two components (Figure 1) (Independent Science Group 1996).

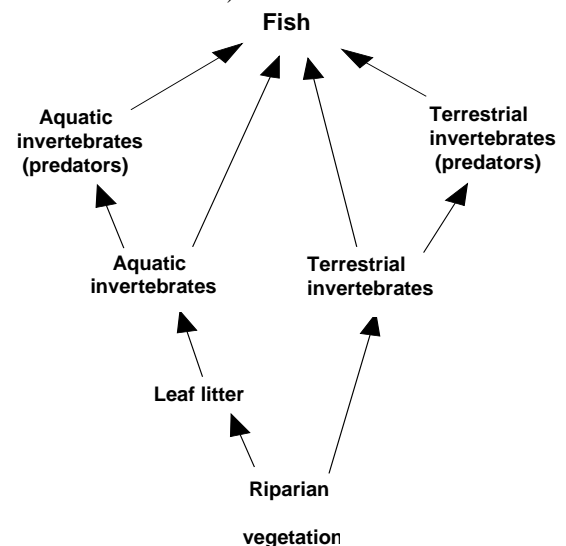


Figure 1. An aquatic food web showing pathways linking riparian inputs to fish.

Disruptions of riparian zones have a long history, and in the Pacific Northwest (PNW) have coincided with the decline of the Pacific salmonids (Nehlsen et al. 1991, Gregory and Bisson 1997). In the mid-nineteenth century, when pioneers arrived in the fertile valleys of the Pacific Northwest, high diversity riparian forests lined most river floodplains (Sedell and Frogatt 1984). Since that time, channelization, grazing, agricultural activities, water withdrawal, and flood control have dramatically reduced these

riparian forests and constrained interactions between streams and their adjacent riparian forests (McGill 1979, Swift 1984, Decamps 1993, Kauffman 1988, Gregory and Bisson 1997, Kauffman et al. 1997). Physical shading of the stream by riparian vegetation also influences stream temperatures, which can be limiting to salmonids (Li et al. 1994, Tait et al. 1994).

Riparian Succession over time:

Riparian vegetation rapidly recolonizes a site following disturbance, either natural or anthropogenic, and succession is thought to proceed by predictable changes in vegetation communities (Figure 2). A site's successional trajectory will influence its present state. A normative system (*sensu* Independent Science Group, Return to The River 1996) will be characterized by a dynamically changing riparian zone in which disturbances, such as floods, create areas for early successional stages, while other areas maintain more mature communities. In many human dominated landscapes, riparian zones are primarily comprised of early seral stages of vegetation, with low vegetation and channel diversity.

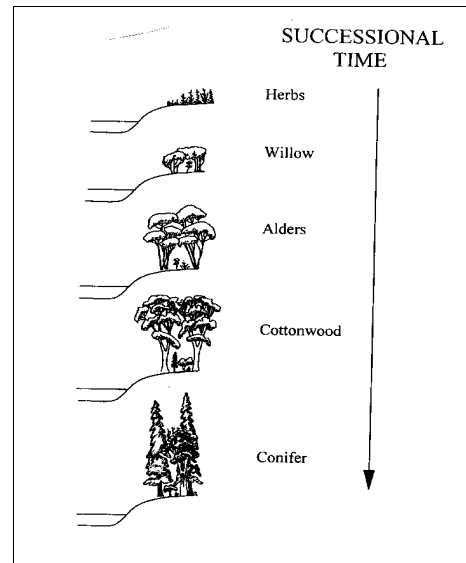


Figure 2. Simplified riparian vegetation succession

Historical and current aerial photography, in combination with ground truthing techniques, provide powerful tools in examining large-scale connectivity. Historical analyses can provide the context for current riparian vegetation conditions and pathways for successional states (Decamps et al. 1988). They help infer the mechanisms that created the present “snapshots” in time. Using the same techniques, viewing the landscape at watershed and regional scales, we also can develop a spatial context for upstream or upslope influences on site dynamics, as well as downstream or network impacts of particular sites. Thus our emphasis on riparian succession dynamics expands the scope of our work beyond reach or site specific phenomena to include connections with historical, watershed, and regional processes. Indeed, these are the scales at which salmonids respond and at which stream restoration will be measured.

Human Dimensions and Management Ramifications:

As the Northwest region farmers implement new management strategies of riparian restoration, understanding critical linkages between structure and function of riparian ecosystems and their streams is essential. Historical records and photographs suggest that many of the river floodplains in the northwest valleys were lined with cottonwood, alder or willow riparian galleries, but few remain intact. These river basins once provided extensive habitat for anadromous and resident fishes. The trajectory of declining salmonid abundances continue despite millions of dollars invested by agencies such as USDA Forest Service, BPA, and BLM. Although numerous factors contribute to these declines, food resources and habitat availability are key factors.

In addition to historical and present impacts of disturbance on riparian vegetation connectivity and diversity, plantings of exotic riparian vegetation (e.g. Russian olive) and the potential of hybrid poplar monocultures could disrupt riparian processes. Recent interest in hybrid poplars as harvestable riparian species may confound problems associated with an exotic species and lowered biodiversity. In Europe, plantations of exotic monocultures have replaced the natural diversity of riparian vegetation along stream banks of various watersheds (Cortes et al. 1994). This has changed the trophic structure of affected streams and influenced the input of terrestrial invertebrates that form the bulk of drifting prey for surface feeding

fishes in headwater streams. The timing and quality of litter inputs from single species plantings or exotic species may differ greatly from diverse systems and lead to reduced food resources for aquatic species.

The sustainability of watersheds of the Pacific Northwest will depend on a complex blend of social, political, biological and physical realities (Gregory and Bisson 1997). Efforts in progress to save salmonid stocks will require participation by agricultural, forestry and urban interests, a political willingness for regional cooperation, and investment in empirical studies to find appropriate ecological solutions. Our study addresses the latter and relates to pending riparian restoration initiatives that may result in simplifying riparian gallery forests on a landscape scale. As we address phenomena associated with biodiversity in these ecosystems, we also will provide a basic understanding of processes fundamental to riparian influences on salmonids in eastern Oregon.

Research Questions:

How do aquatic food webs compare among streams associated with riparian zones differing in seral stage or diversity?

- A. How does the timing, duration, variety, and nutritional quality of litter inputs into the stream differ from diverse riparian stands versus those with low diversity?
- B. How are the diversity and standing crops of aquatic invertebrates related to the timing, duration, variety, and quality of litter inputs?
- C. How is the quantity of terrestrial invertebrate input related to riparian diversity?
- D. What are the cumulative downstream effects of riparian diversity?

How is the production of juvenile salmonids and sculpins affected by riparian diversity?

- A. Is feeding behavior of stream fishes affected by riparian diversity?
- B. How does the quality and quantity of available food affect feeding location and prey choice?
- C. How does the quality and quantity of food affect feeding rates and quantity of food ingested?
- D. Is production of juvenile salmon and sculpins correlated with average stomach contents?

Riparian Strategies:

In riparian ecosystems, mixed woody and herbaceous species potentially provide a rich diversity of nutritional and structural resources to streams that run through them. Energy transfer from riparian zones to streams occurs not only in the form of vegetative litter but also as herbivorous terrestrial insects that become food for drift-feeding fish. We expect that greater riparian species diversity will support more varied herbivorous insect species (Figure 3). If host plant species are not present, loss in associated herbivorous species may reduce numbers or growth of salmonids in the adjacent stream. The availability to fish of aquatic invertebrates, particularly those dependent on litter inputs also will be linked to riparian diversity (Figure 3).

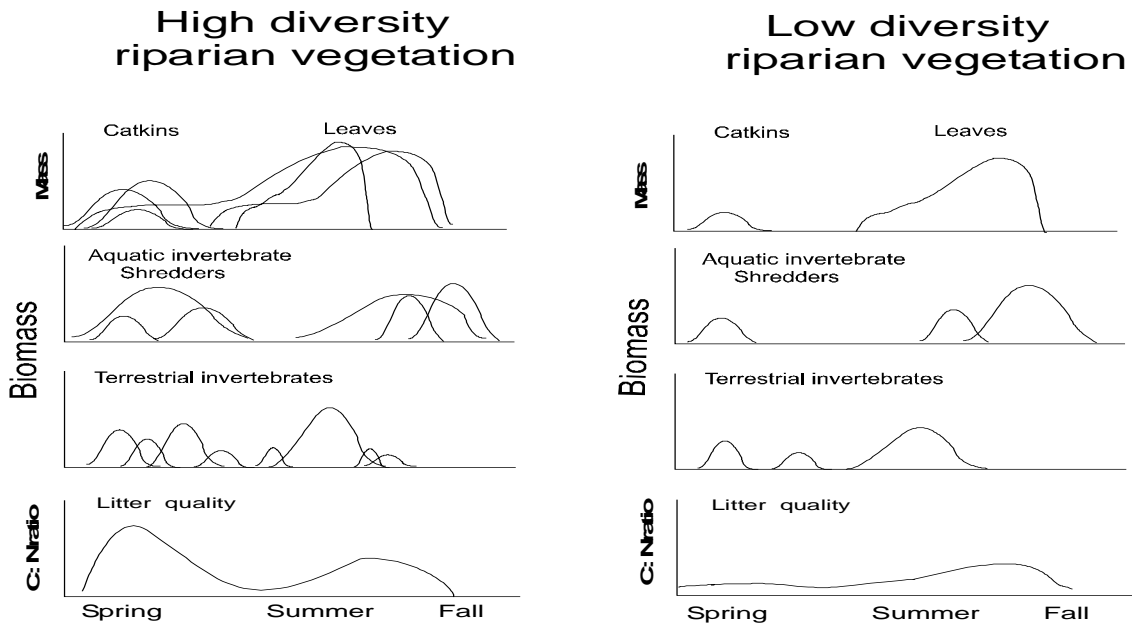


Figure 3. Contrasting hypothetical seasonal availability of biomass of riparian inputs, nutritional quality and invertebrate abundances from two riparian areas of differing seral stage.

We suspect that a major difference between less diverse or monocultural riparian stands and diverse riparian stands is the phenology of allochthonous input into streams. Simple riparian stands may have only one leaf input time during the year, whereas diverse communities will have broader intervals of input, depending upon the species mix (Figure 3). This timing of inputs will have significant ramifications with respect to energy transfer to the stream and the composition and production of stream invertebrates and fishes. We suspect that nutritional quality of the inputs may also vary among seasons, but quantity may override nutritional values in some seasons or locations.

Our hypotheses focus on how terrestrial diversity influences stream communities, but other characteristics of sustainable riparian ecosystems will also emerge. As we compare historical vegetation patterns to current ones issues of fragmentation and degrees of connectivity will be important. We expect that measures of retentiveness and downstream effects will reveal the importance of longitudinal connectivity in the stream network. Our approach will be to examine upstream and downstream effects in close proximity to the focal riparian site. The length of the downstream effects will be calibrated by drift and retention measures because we recognize that longitudinal effects, particularly for suspended particles, could occur over much greater distances than generally recognized (Johnson and Covich 1997).

b. Rationale and significance to Regional Programs

Overall, this proposal supports the systemwide goal of a healthy Columbia River Basin (Section 2.1) by conducting research that addresses the role of current riparian and stream habitat conditions on aquatic productivity and ultimately fish production. This proposal specifically meets the intent of the Columbia River Basin Fish and Wildlife Program, Northwest Power Planning Council Sections 2.1, 2.2A, 4.1A, 7.6D, 10.2, 10.7, and Appendix A. As suggested in the NPPC (Sections 2.1, 2.2A, 4.1A, 10.2), managing the basin effectively requires an approach that evaluates the health of the natural/whole system. In addition, this project meets many of the principles outlined in Section 4.1A, including activities that will aid in rebuilding weak upriver populations, approaching habitat analysis from a total watershed perspective, and addressing critical uncertainties and testing important hypotheses.

Approximately 80% of the Columbia River drainage lies within the high desert east of the Cascades. Historical records and photographs suggest that forests of riparian obligates dominated many of the floodplains in this region, but few riparian forests remain intact. These riparian zones have significant roles in maintaining habitats for native species, as discussed in Return to The River (Independent Scientific Group 1996) and supported by NPPC Section 2.2A. This study will include the Umatilla River Basin where significant native riparian stands remain. Though numerous factors contribute to the decline of native fishes, habitat availability and food resources are essential factors. Habitat objectives of the NPPC (7.6D and Appendix A) stress the importance of riparian vegetation in providing bank stability, water quality, and food resources for fish. Monitoring of riparian vegetation trends has been recommended and plantings are suggested for areas with declining trends (Appendix A and Section 10.7). Major new initiatives, particularly CREP, are underway to implement riparian plantings as an active approach to riparian and stream restoration in the Pacific Northwest. However, without fundamental understanding of successional processes in riparian ecosystems and the effects of diverse riparian vegetation stream communities (Independent Scientific Group 1996), there will be high uncertainty about the impacts of riparian restoration strategies on stream fishes. This proposal will begin to address these questions and reduce scientific uncertainties associated with stream restoration.

c. Relationships to other projects

For more than a decade we have been engaged in watershed-level studies of salmonids in eastern Oregon. We have collaborated with extensive fish surveys conducted in cooperation with ODFW's BPA grant (to D. Buchanan, P. Howell and A. Hemmingson) studying bull trout distribution and biology, U. S. Fish and Wildlife's grant (to J. Dambacher, K. Jones and H. Li) determining redband trout distribution, and our NSF/EPA Watersheds grant (to H. Li, J. Li, B. Kauffman, P. McDowell and B. McIntosh) of the John Day, Wineha and Grande Ronde basins. Our interests include distribution of these salmonids, biological interactions and physiological responses. Our NSF/EPA Watersheds grant explored salmonid response to hydrologic and geomorphic riparian connectivity, and collaboration with the Umatilla National Forest (with K. Clifton) continues our studies in floodplain dynamics. We are collaborating with DEQ (through B. Hemmond) in examining temperature-related problems for redband trout. Our previous interests in stream invertebrates continues in collaboration with the Umatilla National Forest (J. Sanchez and C. Hirsch) studying effects of mining restoration on invertebrates and fish. We have explored temperatures along stream corridors on a landscape scale through FLIR "snapshots" in time. Both the Confederated Tribes of the Umatilla Indian Reservation (with R. George) and the Confederated Tribes of Warm Springs (with S. Robertson) are collaborating with us in funding and analyzing these landscape scale images. Dr. Reed has been working with the Confederated Tribes of the Umatilla Reservation in preparing for the proposed study.

We also will be collaborating and principal investigators on other projects submitted to BPA. Dr. Kauffman's proposed extensive geomorphic and hydrologic survey of stream restoration projects will provide a wider physical and spatial context to our more intensive study of riparian interactions. We recognize that riparian zones contribute not only allochthonous debris and structural features, but also provide cooler temperatures. Dr. H. Li's proposal examining temperature effects on salmonid physiology and distribution will compliment our study by delineating physiological responses in habitats at varying temperatures. We will make site selection and study design to maximize joint opportunities with all these projects.

d. Project history (for ongoing projects)

e. **Proposal objectives**

Our research will determine the role of riparian plant diversity, structure and density, on stream food webs and fish abundances.

Specifically we want to examine:

1. Changes in riparian vegetation composition, structure and successional stage over time.
2. Current riparian vegetation diversity and physical habitats of streams associated with riparian stands at different successional stages.
3. Differences in litter and terrestrial invertebrate inputs from riparian stands of different plant diversity with respect to the phenology of biomass of allochthonous CPOM, the phenology and amount of terrestrial invertebrate input, and biomass of drift.
4. Stream invertebrate response to differences in riparian diversity: community diversity, biomass and phenology.
5. Fish responses to differences in riparian diversity: distribution, diet and growth rate of yoy salmonids.

Hypotheses:

Historical analysis of riparian succession:

Hypotheses: (1) The sequence of riparian succession follows the autecological model shown in Figure 2; (2) Riparian diversity and successional stages reflect disturbance intervals.

Litter/allochthonous inputs of plant material:

Hypotheses: (1) The input of litter and allochthonous material is greater and occurs more evenly throughout the growing season in riparian zones of higher vegetative diversity; (2) The quality of litter (C:N), especially spring inputs, is greater in diverse riparian zones (Figure 3).

Terrestrial invertebrate associations with riparian diversity and succession:

Hypotheses: (1) Standing crops and species richness of terrestrial invertebrates are higher in riparian zones of higher diversity; (2) Composition and biomass of herbivorous invertebrates associated with diverse riparian zones provides an optimal food supply for salmonid young of year (YOY); (3) Native plant material supports more invertebrates than exotic species.

Influence of allochthonous inputs of plant material to stream invertebrates:

Hypotheses: (1) Food resources for aquatic invertebrates are of greater quantity and higher quality in riparian zones with high diversity; (2) Standing crops of aquatic invertebrates are higher in areas of greater riparian diversity; (3) Invertebrate species richness is higher in areas of greater riparian diversity.

Stream drift: invertebrates, allochthonous and autochthonous contributions

Hypotheses: (1) Higher drift biomass will be associated with areas of greater riparian diversity, where allochthonous drift exceeds autochthonous drift; (2) Quality and quantities of drift will be less variable among seasons in reaches with high native plant riparian diversity.

Influences of stream morphology and habitat complexity:

Hypothesis: Riparian zones of higher diversity will have fish habitats of higher complexity and have lower rates of heat gain than less diverse systems.

Fish responses:

Hypotheses: In riparian zones with higher diversity: (1) On average, YOY salmonids will have higher stomach fullness and faster growth rates than in those with less; (2) Allochthonous prey will constitute a higher fraction of the diet than autochthonous stream invertebrates; (3) Fish densities will be higher.

f. **Methods**

Site Selection: We will examine the influence of riparian ecosystem diversity on stream invertebrates and fish using a regression design to establish multiple study reaches on three streams (3rd to 5th order) in north-eastern Oregon. Based on aerial photo analysis and site inspection, we will choose study streams containing at least one site with high riparian diversity and having a range of riparian conditions along their length. We will control for factors of elevation, insolation, irrigation, stream gradient, aspect and stream

size. Watershed council priorities, federal and state agency and private landowner interests will also contribute to site choice.

Low-altitude remote sensing will be conducted with a helicopter using a forward-looking infrared (FLIR) thermal imager and digital color day video. The FLIR will be used to map longitudinal temperature profiles and thermal heterogeneity of study streams (Torgerson et al. in press). We will use visible video to evaluate riparian vegetation stands and to digitize stream channels for the base GIS coverage for all the study datasets. All datasets will be geo-referenced using GPS and attached to an Arc/Info GIS.

Analysis of riparian succession: Current floodplain vegetation composition will be mapped utilizing standard (1:12,000) or low level aerial photos coupled with extensive ground truthing. Riparian diversity will be defined as high woody and herbaceous species richness and evenness. Entire reaches will be walked to visually confirm vegetation communities that will be mapped onto mylar. Through ground truthing, we have found that species composition can be accurately identified on aerial photos. Knowledge of current composition and the unique textural patterns of plant species on the photographs can be used to accurately determine historical vegetation. We propose to reconstruct riparian community succession by analyzing time series of aerial photographs of riparian zones in different areas. We will determine vegetative structure and density, community type and spatial extent of the riparian zone. We can determine stand age through back calculations from images within the time series, which will be checked by site visits and identification of distinctive trees.

Riparian vegetation composition, structure and diversity: Methods to quantify riparian vegetation will closely follow those previously developed in Northeast Oregon (Case 1995, Kauffman et al. 1985). At the upstream, middle, and lower ends of each sampling reach, three 25 x 25 m macroplots will be established. Each plot will begin at the low water line of the stream. All trees >10cm dbh will be measured for species, diameter, and height in the entire macroplot. Trees of sizes 0-10 cm dbh will be measured in a 10x 25m plot, within macroplots. Tree seedlings, shrubs and herbaceous material will be quantified in 5 1x1m nested microplots within each macroplot. Species richness, species diversity, and structural diversity will be calculated for each reach. Biomass and plant density also will be quantified. Additional indices will be calculated for native and exotic species. We will calculate Alpha diversity, (defined as the species richness of the individual macroplots), Gamma diversity, (species richness of all sample plots) and beta diversity (alpha/gamma diversity). This allows for comparison of relatively intact vs. perturbed streams at multiple spatial scales. All these parameters will be used to test multiple hypotheses regarding riparian diversity correlations to aquatic diversity.

Stream habitat characterization: At each reach, we will evaluate habitat using a combination of ground surveys and low-altitude remote sensing to quantify and characterize stream morphology and habitat complexity. Habitat surveys will be conducted using Hankin and Reeves (1988) methodology to quantify fish habitat and its distribution within the study reaches. We will delineate the distribution of habitat types, substrate conditions, woody debris, undercut banks, and stream features from ground surveys. Hourly water temperature at sites will be monitored. We will examine whether reaches with high riparian diversity also have high instream retentiveness through leaf and krill releases. Fluorescence dye releases will be used to examine hydraulic retention and stream spiraling.

Allochthonous inputs: In each of the sampled reaches, allochthonous inputs will be quantified via litterfall traps and annual surveys of large wood debris. Litterfall will be quantified utilizing four 25 X 75-cm traps suspended over the stream surface. In addition, four paired perpendicular traps will be placed on the stream's edge to capture the lateral inputs. Litter will be collected every 2-4 weeks with more frequent collections during the spring and autumn months. Litter will be separated into leaves, needles, wood materials (twigs, cones, bark), lichens/moss, reproductive parts (flowers, catkins, and seeds), dried and weighed (Johnson and Covich 1997). Any terrestrial invertebrates will be separated and identified. Collected allochthonous materials will be transported to the lab and analyzed for carbon and nitrogen content utilizing a Carlo-Erba NCS analyzer.

Four drift samples/site will be collected using nets of 1000-micron mesh nested within 363 micron mesh, set monthly. Water velocity will be measured upstream of each net in order to calculate the volume of water being filtered. Aquatic and terrestrial invertebrates will be separated from the detrital material and identified. Invertebrates will be dried and biomass calculated. Voucher specimens will be retained in the OSU Department of Fisheries and Wildlife. Collected detritus will be separated into plant categories; percent of each leaf type comprising the sample will be quantified before being dried (60 °C) and ashed (500 °C) (Johnson and Covich 1997).

Invertebrate sampling: Aquatic invertebrate samples at focal sites will be collected monthly when riparian vegetation is in leaf or dropping leaves into the stream (approximately March-November). At each site, six replicate benthic collections will be made with a 0.09 m² Surber sampler, stored in 70% ethanol (Hauer and Resh 1996), and enumerated under a laboratory microscope. Subsamples will be dried and biomass calculated. Visual counts of large-bodied invertebrates will be made using a 0.1 meter water scope (Li 1990) traversing five transects perpendicular to flow.

Estimates of terrestrial invertebrate abundance and diversity will be obtained from organisms separated from overhead litter traps and from sticky traps. Abundance will be determined by counting individual organisms and by drying collections for dry biomass. Sticky traps will be set for 24h at a time, with 6 traps/site. These will be frozen immediately for later identification (M. Molles, personal communication).

Fish sampling: Fish collections will follow the methods of Li et al. (1994) and Li and Li (1996). We will try to minimize electrofishing for density estimates by counting salmon and trout in riffles and pools visually (Li et al. 1994). This will be done for all habitat units in each study reach. Estimates of production will require estimates of average size of the YOY populations through time; this necessitates capturing fishes. We can lessen the intrusive nature of electroshocking by sampling different habitat units (riffles for sculpins, pools and riffles for salmonids) instead of fishing entire reaches. Habitat units will be selected at random during each sampling period. A power test will be conducted to determine the minimum number of samples necessary to detect differences among reaches. Fishes collected will be measured, weighed and stomach pumped (Bowen et al. 1983). Each sampling effort will serve many purposes, again minimizing the number of fish handled. The sampling will be nondestructive, in accordance with nationally accepted animal health and safety standards, and fish will be released back into the stream.

g. Facilities and equipment

Computers: Pentium PC personal computers, McIntosh 8100 computers, laser printers, scanner, data servers, and connection to email and the internet.

GIS: a complete GIS laboratory, including digitizers, work stations, ArcView, ArcInfo, and frame grabbing GIS software, GPS units, and digital video camera.

Software: Word processing: Word, WordPerfect; Data management and graphics: Excel, QuattroPro, SigmaPlot, CorelDraw; Statistical analysis: Systat, SAS, BMDP; Bibliographic software: Procite, Papyrus, Absearch.

Field Equipment: aquatic insect collecting gear, 40 recording thermistors, electrofishers, solar pathfinders

Analytical laboratories: fully equipped analytical laboratory, laboratory space and a dissecting microscope for sorting and identifying invertebrates and drying leaf litter.

University Facilities: The university provides offices, communications, book keeping services, and university library.

h. Budget

This is a proposal for team research, and many responsibilities will be shared by personnel at all levels. The following description lists where major duties will be assigned. All students will receive tuition and full-year stipend (12 months).

Allochthonous litter, aquatic invertebrate and fish diet:

J. Li (3 months salary), 1 graduate student, 1 Research Assistant (12 months salary)

S. Johnson (3 months salary)

Historical and current aerial photo analysis, FLIR imagery:

B. McIntosh (3 months salary), .75 Research Assistant (9 months salary)

Fish behavior and enumeration:

H. Li (3 months salary from federal agency, none requested in this grant), 1 graduate student (who will also share duties for photo and FLIR analysis)

Riparian diversity and succession

B. Kauffman (1 month salary), 1 graduate student (who will share duties for allochthonous litter)

Terrestrial invertebrates; coordination with watershed councils

G. Reed (1 month salary), 1 graduate student

Major Supplies:

McIntosh: FLIR – low altitude remote sensing imagery, thermal and visible bands (\$25,000)

Aerial photographs – purchase of copies of historical photos (\$5000)

Johnson: chemical analyses (\$10,000), litter nets (\$1000)

Other Miscellaneous Supplies:

drift nets, flowmeter & electroshocker maintenance, ethanol preservative for invertebrates, photographic supplies, terrestrial traps, laboratory supplies, photocopies

Travel:

Domestic travel from Corvallis to eastern Oregon study sites for all personnel except Dr. Reed from March through November

Regional and national travel to professional meetings (1/team member)

Per diem costs for students during field work

Lodging during inclement weather of March-May, September-November

Non expendable items:

2 computers with printers for use by all team members, particularly 4 graduate students and 2 research assistants for whom we do not have sufficient facilities in current laboratories (\$3000 each)

1 flowmeter dedicated to this project for measurements of streamflow at each sampling time at each site(\$3000)

1 portable scale for field processing of litter and fish (\$2000)

1 drying oven for litter biomasses (\$2500)

1 Fluorometer for retention studies of streamflow using fluoroscene (\$10,000)

Section 9. Key personnel

JUDITH L. LI

Commit 0.25 FTE to Project

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Assistant Professor

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Oregon State University, Corvallis OR 97331-3801.

EDUCATION:

A.B. - Biological Science, University of California, Berkeley, 1966; **M.S. -** University of California, Davis, 1977; **Ph.D.Fisheries**, Oregon State University, Corvallis, 1990.

EXPERIENCE:

Research Assistant Professor, OSU Department of Fisheries and Wildlife /Department of Entomology

January 1997-present; **Research Assistant Professor**, OSU Department of Fisheries and Wildlife (March 1994-1996); Principal Investigator, EPA Surface Waters Program, Development of Macroinvertebrate Sampling Protocols in Western Oregon (1992-1994); **Research Associate**, OSU Department of Fisheries and Wildlife (1991-1994); **Research Director**, Oregon Museum of Science and Industry, NSF Young Scholars Program Aquatic Team (1990, 1993).

EXPERTISE:

Dr. Li is a stream ecologist whose emphasis has been on freshwater invertebrates and their role in aquatic foodwebs. She has been involved in multidisciplinary research in eastern Oregon for 10 years through projects funded by competitive grants from NSF, USFS, and EPA. She has been developing landscape models of macroinvertebrate assemblages for the Inner Columbia River Basin Report (USFS and BLM) and the Willamette Basin (EPA-sponsored PNW Consortium). With her students she has been examining the influence of human activities on aquatic biota in river basins affected by mining, intense recreation, grazing and agriculture.

PROFESSIONAL ACTIVITIES:

North American Benthological Society: Member Executive Committee (1991- 1992;1994-1997); Chair, Task Force on Multicultural Diversity (1991-1994); Chair, Human Relations Committee (1994-present); **American Fisheries Society :**Member, J. Frances Allen Scholarship Committee, (1994-1997); Chair, Education and Information Committee, Oregon Chapter (1991-1994; 1997).

HONORS AND AWARDS:

OSU College of Agriculture, Oldfield Team Research Award (1991); Nominee, **OSU College of Agriculture:** Presidential Award of Excellence in Science, Mathematics and Engineering Mentoring, National Science Foundation (1996); **Special Recognition by American Women in Science as a mentor for women**, 25th Anniversay Celebration, OSU, Jan 14, 1997; **Nomination, Women of Achievement Award**, April 25, 1997; Women's Center OSU

FIVE PUBLICATIONS RELATED TO THIS PROPOSAL :

- Li, H.W., G.A. Lamberti, T.N. Pearsons, C.K. Tait, J.L. Li. 1994. Cumulative impact of riparian disturbance in small streams of the John Day Basin, Oregon. *Transactions of the American Fisheries Society* 123(4):627-640.
- Tait, C.K., J.L. Li, G.A. Lamberti, T.N. Pearsons, and H.W. Li. 1994. Relationships between riparian cover and the community structure of high desert streams. *Journal of the North American Benthological Society* 13(1):45-56.
- Li, H.W. and J.L. Li. 1996. Fish Community Composition. Pages 391-406 in F.R. Hauer and G.A. Lamberti (eds). *Methods in stream ecology*. Academic Press, N.Y., N.Y.
- Lamberti, G.A., S.V. Gregory, L.R. Ashkenas, J. L. Li, A.D. Steinman & D.D. McIntire. 1995. Influence of grazer type and abundance on plant-herbivore interactions in streams. *Hydrobiologia* 306:179-188.
- Herlihy, A., P Kaufmann, L. Reynolds, J. Li, and G. Robison. 1997. Developing indicators of ecological condition in the Willamette Basin: an overview of the Oregon prepilot study for EPA's EMAP Program. pp. 275-282. *In* River quality, dynamics, and restoration. A. Laenen and D.A. Dunnette (eds.), CRC Press, Boca Raton, FL.

SHERRI L. JOHNSON

Commit 0.25 FTE to Project

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Research Associate
Department of Fisheries and Wildlife
Oregon State University
Corvallis, OR 97331

EDUCATION:

BA - Environmental Biology, University of Montana, Missoula, 1989; **MS - Zoology**, University of Oklahoma, Norman, 1991; **Ph.D. - Zoology**, University of Oklahoma, Norman, 1995.

EXPERIENCE:

NSF Research Fellow, Department of Geosciences, Oregon State University, 1996-present; **Research Scientist**, Department of Zoology, University of Oklahoma, 1995-1996.

EXPERTISE:

Dr. Johnson is a stream ecologist who has conducted successful research examining riparian controls of allochthonous distributions at multiple spatial and temporal scales along river gradients. Research has focused on biotic responses to physical disturbances (floods, hurricanes, human activities) through changes in availability of food resources and habitats. Her current research involves analysis of terrestrial/stream interactions (geomorphic analysis of flood induced channel changes as well as examination of controlling mechanisms of stream temperatures).

HONORS AND AWARDS:

National Science Foundation Post-doctoral Fellow, 1996-1998; **University of Oklahoma Centennial Research Fellowship**, 1991-1995.

FIVE PUBLICATIONS RELATED TO THIS PROPOSAL:

- S.L. Johnson and A.P. Covich. 1997. Scales of observations of riparian forests and distributions of suspended detritus in a prairie river. *Freshwater Biology* 37: 163-175.
- S.L. Johnson and C.C. Vaughn. 1995. A hierarchical study of macroinvertebrate recolonization of disturbed patches along a longitudinal gradient in a prairie river. *Freshwater Biology* 34:531-540.
- S.L. Johnson, G.E. Grant, F.J. Swanson, and B.C. Wemple. 1997. Lessons from a flood: an integrated view of the February 1996 flood in the McKenzie River basin. Pages 159-167 in A. Laenen (ed.) *The Pacific Northwest Flood of February 1996, Proceedings of the Pacific Northwest Water Issues Conference*, American Institute of Hydrology, .
- S.L. Johnson. 1993. Cover choice by bluegills: Orientation of underwater structure and light intensity. *Transactions of the American Fisheries Society* 122:148-154.
- A.P. Covich, T.A. Cowl, S.L. Johnson, and M. Pyron. 1996. Distribution and abundance of tropical freshwater shrimp assemblage along a stream corridor: response to disturbance. *Biotropica* 28:484-492.

HIRAM W. LI

Commit 0.25 FTE to Project

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Professor and Assistant Leader

Oregon Cooperative Research Unit,

Department of Fisheries and Wildlife

Oregon State University, Corvallis OR 97331-3801.

EDUCATION:

A.B. - Zoology, University of California, Berkeley, 1966; **M.S. - Fishery and Wildlife Biology**, Colorado State University, 1973; **Ph.D. - Ecology**, University of California, Davis, 1973.

EXPERIENCE:

Professor and Assistant Leader, Oregon Cooperative Fishery Unit, Department of Fisheries and Wildlife, Oregon State University. 1988-Present; **Associate Professor and Assistant Leader**, Oregon Cooperative Fishery Unit, Department of Fisheries and Wildlife, Oregon State University. 1979 to 1988; **Assistant Professor**, Department of Wildlife and Fisheries, University of California, Davis. July 1973 to January 1979.

EXPERTISE:

Dr. Hiram Li's nationally recognized expertise is in the community ecology of freshwater fishes, as well as landscape and stream ecology. He has spent the past decade doing research in the Blue Mountain Ecoregion examining the relationship of riparian condition and its relationship to the ecology of salmonid bearing streams.

PROFESSIONAL ACTIVITIES:

Ecology Advisory Panel for the National Science Foundation 1984-1987; **Associate Editor** for Transactions of the American Fisheries Society 1986-1988; **Foley-Hatfield Congressional Team** on Eastside Forest Health Assessment, 1992-1993; **Referee** for 14 primary journals

HONORS AND AWARDS:

Commendation Award, Sport Fishing Institute (1978); **Quality Performance Awards**, U.S. Fish and Wildlife Service (1982, 1989, 1990, 1991); **Director's Research Excellence Award**, U.S. Fish and Wildlife Service (1991); **Special Achievement Award**, U.S. Fish and Wildlife Service (1992, 1993, 1994); **Outstanding Group Achievement Award, American Institute of Fishery Research Biologists** (awarded to the Cooperative Fish and Wildlife Research Units) (1992)

FIVE PUBLICATIONS RELATED TO THIS PROPOSAL :

- Li, H.W., G.A. Lamberti, T.N. Pearsons, C.K. Tait, J.L. Li. 1994. Cumulative impact of riparian disturbance in small streams of the John Day Basin, Oregon. Transactions of the American Fisheries Society 123(4):627-640.
- Bayley, P.B. and H.W. Li. 1992. Riverine Fishes. Chapter 12. Pages 251-281 in P. Calow, G.E. Petts (eds.). The Rivers Handbook, Hydrological and Ecological, Volume 1. Blackwell Scientific.
- Li, H.W. , K. Currens, D. Bottom, S. Clarke, J. Dambacher, C. Frissell, P. Harris, R.M. Hughes, D. McCullough, A. McGie, K. Moore, R. Nawa, and S. Thiele. 1996. Safe havens: genetic refuges and evolutionary significant units. Pages 371-380, in J. Nielsen (ed.), Evolution and the aquatic Ecosystem: Defining unique units in population conservation. American Fisheries Society. Bethesda MD.
- Tait, C.K., J.L. Li, G.A. Lamberti, T.N. Pearsons, and H.W. Li. 1994. Relationships between riparian cover and the community structure of high desert streams. Journal of the North American Benthological Society 13(1):45-56.
- Li, H.W. and J.L. Li. 1996. Fish Community Composition. Pages 391-406 in F.R. Hauer and G.A. Lamberti (eds). Methods in stream ecology. Academic Press, N.Y., N.Y.
- Note: See above for papers and manuscripts related to remote sensing, FLIR and salmonid research.

BRUCE A. MCINTOSH

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Research Associate
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EDUCATION:

B.S. - Wildlife Biology, University of Montana, Missoula, 1982; **M.S. - Forest Ecology**, Oregon State University, Corvallis, 1992; **Ph.D. - Forest Ecology**, Oregon State University, Corvallis, 1995.

EXPERIENCE:

Research Associate, Department of Forest Science, Oregon State University. 1995 - Present; **Research Assistant**, Department of Forest Science, Oregon State University. 1992 - 1995.

EXPERTISE:

Dr. McIntosh has been conducting research on riverine ecosystems and salmonid habitats in the Columbia River basin for the past nine years. His research has focused on historical changes in riparian and stream

habitats, salmonid life history, and the use of remote sensing for stream and riparian research and monitoring. In addition, he has been involved in several assessments of eastside ecosystems for the Federal Government.

FIVE PUBLICATIONS RELATED TO THIS PROPOSAL:

- McIntosh, B.A. 1995. Historical changes in stream habitats in the Columbia River basin. Ph.D. dissertation. Corvallis, OR: Oregon State University. 175 pp.
- McIntosh, B.A., J.R. Sedell, J.E. Smith, R.C. Wissmar, S.E. Clarke, G.H. Reeves, and L.A. Brown. 1994. Historical changes in fish habitat for select river basins of eastern Oregon and Washington. Northwest Science, 68 (Special Issue):36-53.
- McIntosh, B.A., N.J. Poage, and K. Ronnenberg. 1996. Identification and mapping of stream temperatures in the Illinois River basin using forward-looking infrared technology. Final report to the Rogue Valley Council of Governments, Cave Junction, OR. 27 pp.
- C.E. Torgersen, D.M. Price, B.A. McIntosh, and H.W. Li. *in press*. Multiscale thermal refugia and stream habitat associations of chinook salmon in Northeastern Oregon. Ecological Applications.
- Karalus, R.S., M.A. Flood, B.A. McIntosh, and N.J. Poage. 1997. ETI surface water quality monitoring technologies demonstration. Final report to the Environmental Protection Agency, Characterization Division, Las Vegas, NV. 86 pp.

J. BOONE KAUFFMAN

Commit 0.08 FTE to Project

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Associate Professor
Department of Fisheries and Wildlife
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EDUCATION:

B.S. - Range and Wildlife Science, Texas Tech University, Lubbock, 1978; **M.S. - Rangeland Resources**, Oregon State University, Corvallis, 1982; **Ph.D. Wildland Resource Science/Forest Ecology**, University of California, Berkeley, 1986.

EXPERIENCE:

Associate Professor Dept. of Fisheries and Wildlife, Oregon State University, 1995-present. Assistant Professor (1986-1991), Associate Professor (1991), Dept. of Rangeland Resources, Oregon State University, 1986-1995.

EXPERTISE:

Dr. Kauffman has been conducting research in riparian zone ecology for 20 years. Most of that research has been in Northeast Oregon. He also currently teaches the wetland and riparian ecology course at OSU. Research has focused on the plant ecology, biogeochemistry, and floodplain/stream interactions. His research has primarily been applied in nature with an emphasis on restoration ecology and how land use influences the dynamics of riparian/stream ecosystems. Dr. Kauffman has authored over 100 scientific papers.

PUBLICATIONS RELATED TO THIS PROPOSAL:

- Elmore, W. and J. B. Kauffman. 1994. Riparian and watershed systems: Degradation and restoration. pp. 212-232. IN: Vavra, M., W. A. Laycock and R. D. Pieper (eds.). Ecological Implications of Livestock Herbivory in the West. Society for Range Management, Denver, CO.
- Green, D. M. and J. B. Kauffman. 1995. Succession and livestock grazing in a northeastern Oregon riparian ecosystem. J. Range Management. 48:307-313.
- Kauffman, J.B., N. Otting, D. Lytjen, and R.L. Beschta. 1996. Ecological Principles and approaches to riparian restoration in the Western United States. In: Healing the

rivers. Pacific Rivers Council Eugene, OR.
Kauffman, J. B., R. L. Beschta, N. Otting, and D. Lytjen. 1997. An ecological perspective of riparian and stream restoration in the western United States. Fisheries 22:12-24.
Case, R.L. and J. B. Kauffman. 1997. Wild ungulate influences on the recovery of willows, black cottonwood and thin-leaf alder following cessation of cattle grazing in Northeastern Oregon. Northwest Science 71:115-125.

GARY L. REED

Commit 0.08 FTE to project

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EDUCATION:

B.S. - Entomology, Iowa State University, Ames, IA, 1965; **M.S. – Entomology** (ecology), Iowa State University, 1970; **Ph.D. - Entomology**, Iowa State University, 1974.

EXPERIENCE:

Superintendent & Research Entomologist, Hermiston Agricultural Research & Extension Center, Oregon State University, 1985-Present. **Research Entomologist**, Agricultural Research Service, U.S. Department of Agriculture, 1970-1974. **Research Entomologist**, 1968-1970.

EXPERTISE:

Dr. Reed has extensive understanding of terrestrial invertebrate communities of Northeastern Oregon. His research has focused on human influences on invertebrate densities in agricultural settings. He has examined the impact of integrated pest management control mechanisms on agronomic pest species and on non-target invertebrates in the crop ecosystem as well as conducted research on the impact of insecticides .

PUBLICATIONS:

52 refereed journal articles and 70 plus non-referred and popular technical articles

Section 10. Information/technology transfer

We will transfer information through the following means:

Publications in scientific, refereed journals, graduate student theses; presentation of papers at local, regional and national scientific meetings; College of Agriculture and College of Forestry bulletins and publications, including those of the OSU Extension program.

We believe the interpretation of aerial photographs, historical reconstructions, plant succession in riparian zones, and litter input transfer to aquatic invertebrates and fish lend themselves well to visual presentation for many audiences.

We plan to be involved with local watershed councils and to present results of our work in a timely fashion. We will explore ways in which to transfer scientific findings in print and potentially electronic forms that will be readily accessible to landowners and decision makers. Many farmers and ranchers whom we have met in eastern Oregon use electronic communication (email, WWW) extensively. Therefore we will establish and interpret our findings in a webpage as well as through other media.

We work in landscapes that are the legacy of historical practices. Likewise the practical implementation stemming from our results will be constrained by the same legacy. We plan to identify the

processes critical to normative stream ecosystems in our current landscape, and strive to maximize them. Transfer of information will be facilitated by coordination with landowners and watershed councils from the outset of the project. Joint visits to field sites while the study is in progress and regular presentations to watershed councils will provide personal contacts with landowners who could implement our findings. In a complimentary project developing cooperative networks for decision-making in Willamette watersheds (J. Bolte, principal investigator), we are planning to test the effectiveness of several descriptive techniques to enhance public understanding. Lessons learned from that project will be used in this study.

Congratulations!